Advanced Antenna Testbed

Outputs

- Analysis of some proposed antenna array comparison data.
- Antenna array diversity gain data.
- Angle of arrival input data for adaptive antenna schemes.
- 16-element MIMO response over a conductive ground plane.

The use of wireless mobile personal communications services (PCS) and wireless local area networks (WLAN's) is expanding rapidly. Multiple-access schemes based on frequency division, time division, and orthogonal coding are presently used to increase channel capacity and optimize channel efficiency. Adaptive or "smart" antenna arrays can further increase channel capacity through spatial division. Antenna arrays can produce multiple beams as opposed to a simple omni-directional antenna. Numerous narrow beams can be used to divide space, allowing the re-use of multiple-access schemes, and thereby increasing channel capacity. Adaptive antennas can also track mobile users, improving both signal range and quality. For these reasons, smart antenna systems have attracted widespread interest in the telecommunications industry for applications to third generation wireless systems.

ITS has developed an advanced antenna testbed (ATB) to serve as a common reference for testing adaptive antenna arrays and signal combining algorithms, as well as complete systems. The ATB builds on wideband channel measurement systems previously developed by ITS. These systems use a maximal length pseudo-noise (PN) code generator to apply binary phase-shift keying (BPSK) modulation to a radio channel carrier frequency at the transmitter. The received signal is correlated at the receiver with the known PN code producing an impulse-like response. The impulse response characterizes the channel over a wide bandwidth (up to 50 MHz) about the carrier frequency. Digitization of the received data allows for post-processing to examine various combining algorithms and digital beam forming schemes. Channel sounding can be done continuously or in selected bursts.

Figure 1. 16-element transmit and receive arrays used for MIMO testing at the NIST open area test site (photograph by P. Papazian).

A recent ATB application is a 16-element multiple input, multiple output (MIMO), experiment conducted in FY 2001. Two 16-element MIMO arrays were fabricated and tested and then deployed at the NIST open area test site, as shown in Figures 1 and 2. The objective of the test was to measure the **H** matrix in a known RF environment. This allowed a comparison between the Bell Labs layered space-time (BLAST) theory and the measurement capability of a wideband system using orthogonal coding (Papazian et al. 2002, see **Recent Publications** below).

A transmitter capable of generating 16 orthogonal pseudo-noise codes, one for each transmit element, was designed and fabricated using field programmable gate array (FPGA) technology. The signal received on each antenna element will then consist of the signal from all 16 transmitters after combination by the radio channel. After recording the sixteen receive channels, the 256 element channel matrix **H** can be assembled from the data. The MIMO capacity $\boldsymbol{C}$ for a communications link with n_T transmitters and n_R receivers can then be calculated using the following formula:

$$C = \log_2\left[\det\left(I + \frac{\rho}{n_T} HH^{+}\right)\right] bits/hz$$

where I = identity matrix

ρ = signal to noise ratio

H = complex transmission matrix

H^{+} = hermetian transpose of H

The ATB system is portable; both transmit and receive systems may be van-mounted. ATB measured data can be applied to the design of smart antenna PCS systems, evaluating system performance, channel model development and verification, and large communications system simulations. (See the Tools & Facilities section, p. 67, for more information about the ATB.)

Figure 2. Dipole antenna elements used by MIMO array (photograph by P. Papazian).

Recent Publications

P. Wilson, P. Papazian, and Y. Lo, "A comparison of 1920 MHz mobile channel diversity gain using horizontal and vertical arrays," *IEEE Trans. on Communications*, vol. 49, no. 12, pp. 2068-2070, Dec. 2001.

P. Papazian, M. Gans, Y. Lo, and R. Dalke, "Capacity measurements for a 16x16 BLAST array over a conducting ground plane," in *Proc. IEEE Fall VTC 2002*, Vancouver, B.C., Canada, Sep. 2002.

For more information, contact:
Peter B. Papazian
(303) 497-5369
e-mail ppapazian@its.bldrdoc.gov